Design and fabrication of microelectrode for electrochemical biodetection

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***Abstract*—In this project, we developed a generic microsystem for very low concentration detection and relying on electrochemical measurement. The miniaturized device was designed with an open window in order to put micro droplet. The purpose is to produce a low cost biosensor with the integration of electrical interfaces into such miniaturized system to provide new opportunities for electrochemical sensing where high sensitivity and selectivity towards the analyte are required.**

I. INTRODUCTION

Electrochemical sensors represent next to optical transducers a commercially-proven concept and an attractive mean capable of analyzing the content of a real samples in a highly sensitive, miniaturized and cost-effective manner even *in vivo* [1-3].

Microsystems play an important role in many biological and environmental applications. The integration of electrical interfaces into such miniaturized systems provides new opportunities for electrochemical sensing where high sensitivity and selectivity towards the analyte are requested. This can be only achieved via the working electrode modification, a challenge for compact microsystems. In this work, we demonstrate the benefit of surface electrode modification with derivatives of oxide graphene for the selective detection of gold microelectrodes in a microsystem comprising a Pt counter and an Ag/AgCl reference electrodes. The functionalized microsystem was successfully applied for the sensing of dopamine with a detection limit of 50 nM.

II. MICROFABRICATION

The design of the microelectrodes is based on a three classical electrodes system (reference, auxiliary counter and working electrodes), using standard optical lithography on a glass substrate. Special photoresist is intended for lift-off-techniques which call for a negative wall profile. Standard positive photoresist is spin-coated onto a glass wafer and exposed to UV light through a photolithographical mask. The non-polymerized resist is removed with specific developer. Sputtering is then used to deposit a titanium adhesion layer followed by a layer of gold (working electrode) and platinum (counter-electrode and connectors). For the fabrication of the reference electrode, electron beam evaporation is used to deposit a titanium adhesion layer followed by layer of silver (reference electrode). By subsequently removing all photoresist (lift-off) after each deposition, the metal layers are left in the desired positions on the glass. Finally, silicon dioxide is then deposited on the device using inductively-coupled plasma chemical vapor deposition (ICPECVD), allowing the deposition of an analyte droplet onto the microsystem for measurement. To insure a pin-hole free protection layer, photoresist SU8 was in addition deposited using spin coating and polymerized using a photolithographical mask, followed by dissolution of uncured polymer with SU-8 developer.

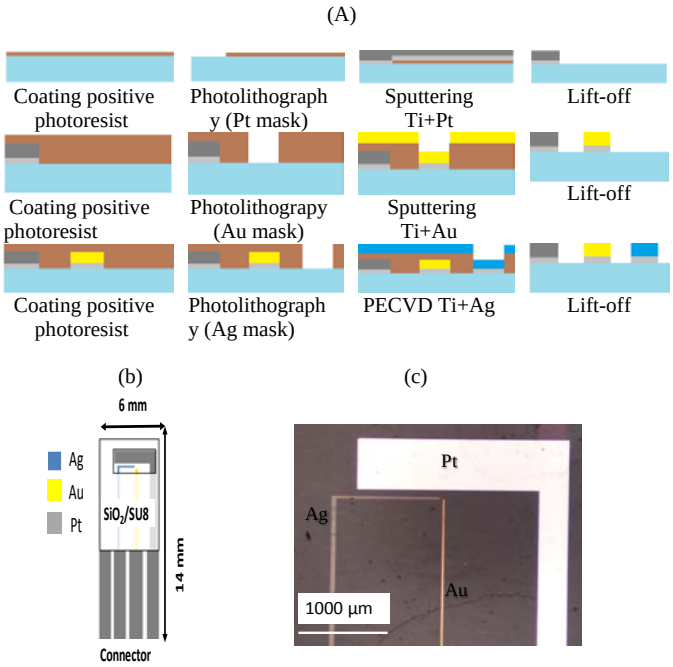

Figure 1. (A) Process flow chart of the fabrication steps used for the generation of the electrochemical microsystem; (B) Schematic drawing of electrochemical microsystem (C) optical image zoomed onto the three electrode configuration.

III. ELECTROCHEMICAL DTECTION

The principle of this concept is to prepare the surface working electrode with biochemical molecule for detecting specific analyte and converts biological response into electrical signal via cyclic voltammetry (CV) measurements. This is the way to explore the

electrochemical characteristics and performance of the device. Firstly, we cleaned the electrodes with acetone flowed by alcohol and drying with nitrogen stream, we should precise that the cleaning recipe depends of the state of each electrode. It is also possible to use chemical and electrochemical cleaning until obtaining a stable signal like as shown in figure 2, then the device is ready for surface modification to achieve modified electrode based microsystem.

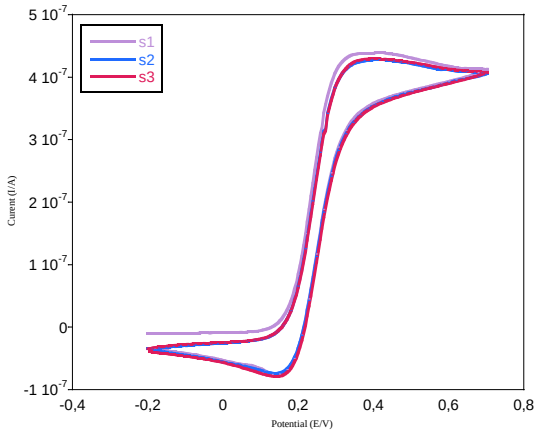

Figure 2. 10 mM potassium hexcyanoferrate II in 0.1 Mm in PBS at 50mV/s

The sensor that integrates a biological element with a physiochemical transducer to produce an electronic signal proportional to a single analyte. Carbon based materials are considered as very good candidate electrode material due to their wide anodic potential range, low residual current, chemical inertness, ease of processing, availability and low cost [4, 5].

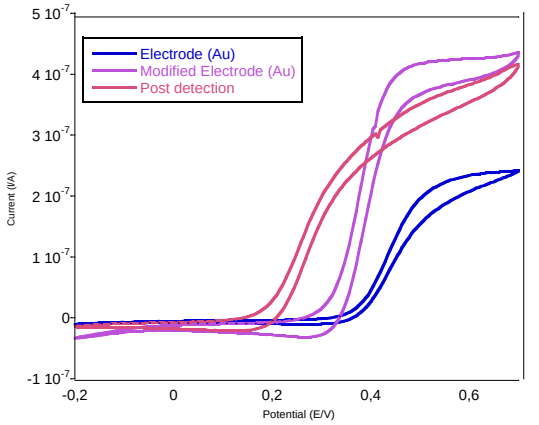

Figure 3. 10 mM potassium hexcyanoferrate II in 0.1 Mm in PBS at 50mV/s

IV. Conclusion

We have successfully developed a generic microsystem, with selective functionalization of a gold microelectrode which was modified with a thin layer of derivative graphene to achieve high electrochemical response of the functionalized electrode. The perspective of this work is to develop a bio-inspired microsystem towards pathogenic detection of bacteria in nosocomial diseases as a proof of concept of our generic microdevice.

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